

# Improving Pomegranate Fertigation and Water-Nitrogen Use Efficiency with Drip Irrigation Systems

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## Supports/Contributors

CDFA/Fertilizer Research and Education Program

Paramount Farming Company

LAKOS

TORO Irrigation

NETAFIM

SDI+

Verdegaal Brothers

# 2015 Research Objectives

**To optimize water-nitrogen interactions to improve Water- and N-use efficiencies of Pomegranate and minimize N-leaching losses**

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- a. Determine the effect of three rates of N-fertigation of pomegranate with High Frequency Drip Irrigation and Subsurface Drip Irrigation on N leaching losses.
- b. Determine the seasonal N requirement of DI- and SDI-fertigated pomegranates which improves NUE without yield reduction.
- c. Determine the seasonal water requirement of HF DI- and HF SDI-fertigated pomegranates which improves WUE without yield reduction.

# IRRIGATION/FERTIGATION SYSTEMS

**TORO Microirrigation, Drip In Classic with Rootguard**, 0.620 in. diameter, 0.53 gph, 0.045-in. wall thickness, 18-in emitter spacing, Installed 3.5 ft. on each side of the tree row.

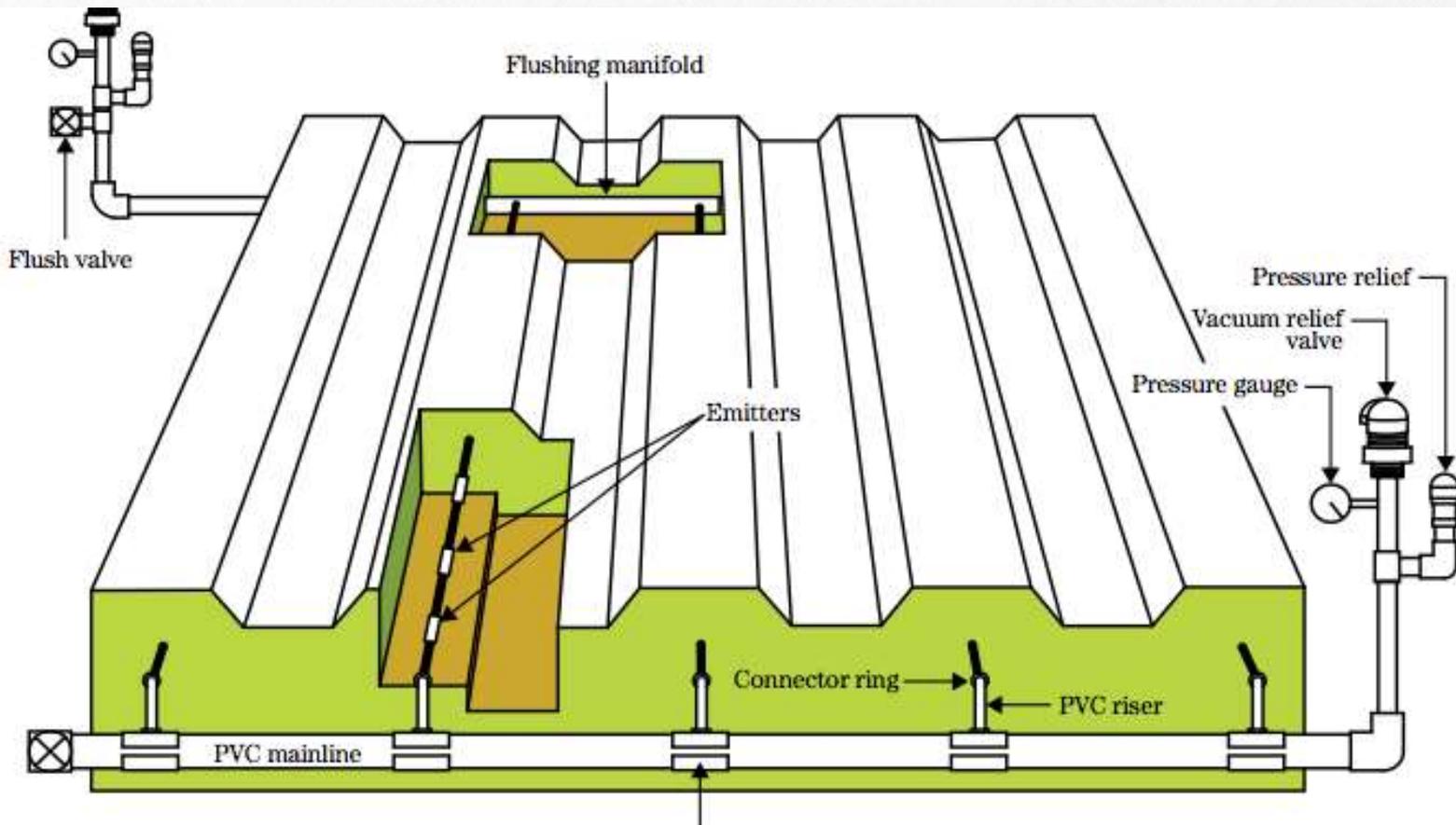
**SDI** laterals are installed at 20-22-in. depth.

**Irrigation scheduling** Fully automated, based on hourly ETC from lysimeter to apply same water volume as lysimeter (2.64 gal/tree/SDI irrigation and 2.84 gal/tree/DI irrigation).

**Fertigation**, N-P-K injected with irrigation water at rates to meet plant requirements, based on bi-weekly plant tissue analyses.



# BASIC SDI SYSTEM DESIGN





6 ft./1.8m lateral spacing  
22 in./0.57m deep

Emitters: 0.53 gph  
18 in./ .47m spacing

Installation of Subsurface Drip Irrigation (SDI) line at 20-22 in. depth

N-pHURIC *Siv*

AN-20

Phos  
Acid

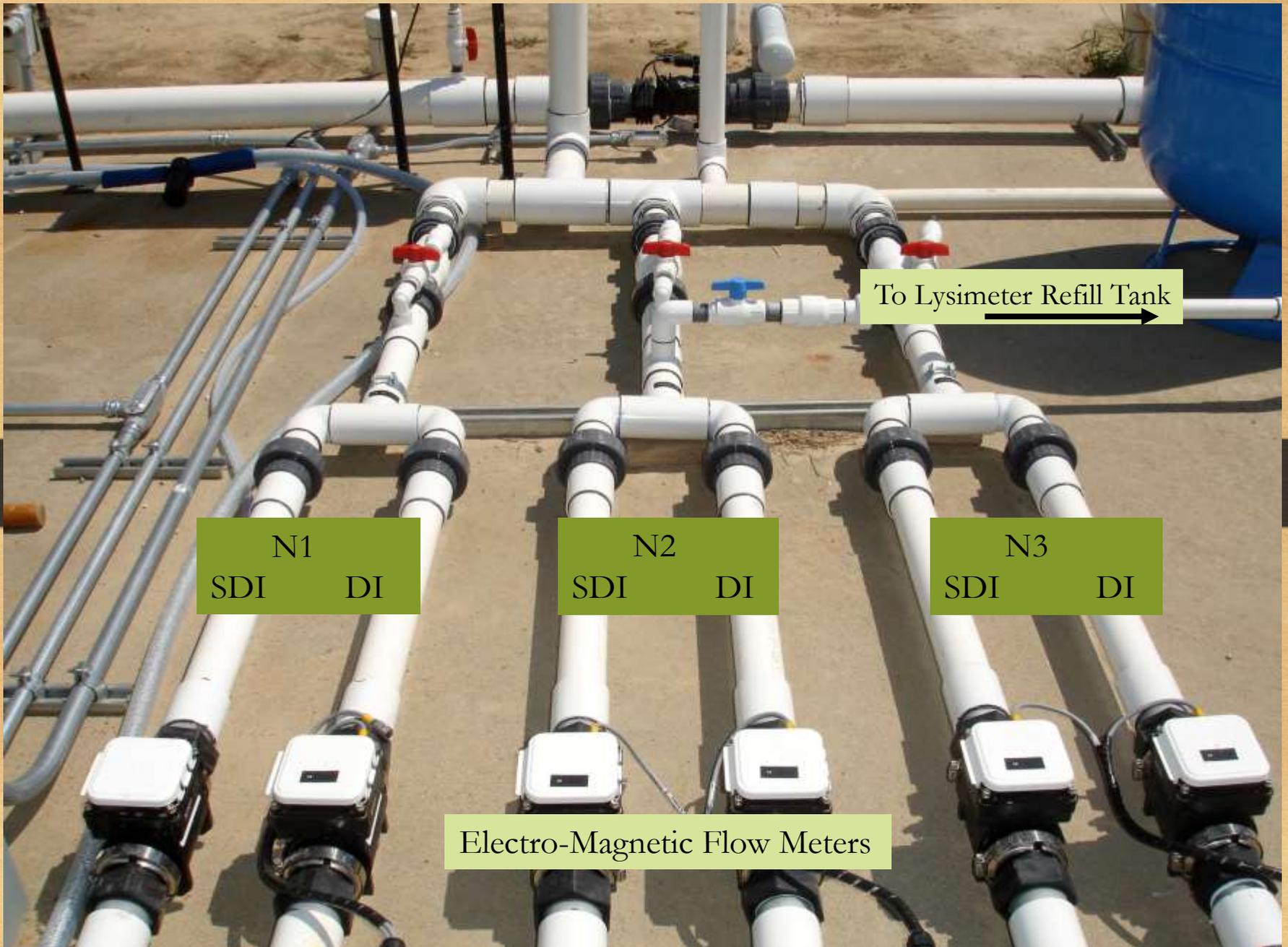
K<sub>2</sub>T

Lysimeter  
Solution  
Refill Tank

pH & EC<sub>w</sub>  
meters

Sand Media Filter





To Lysimeter Refill Tank  
→

N1  
SDI    DI

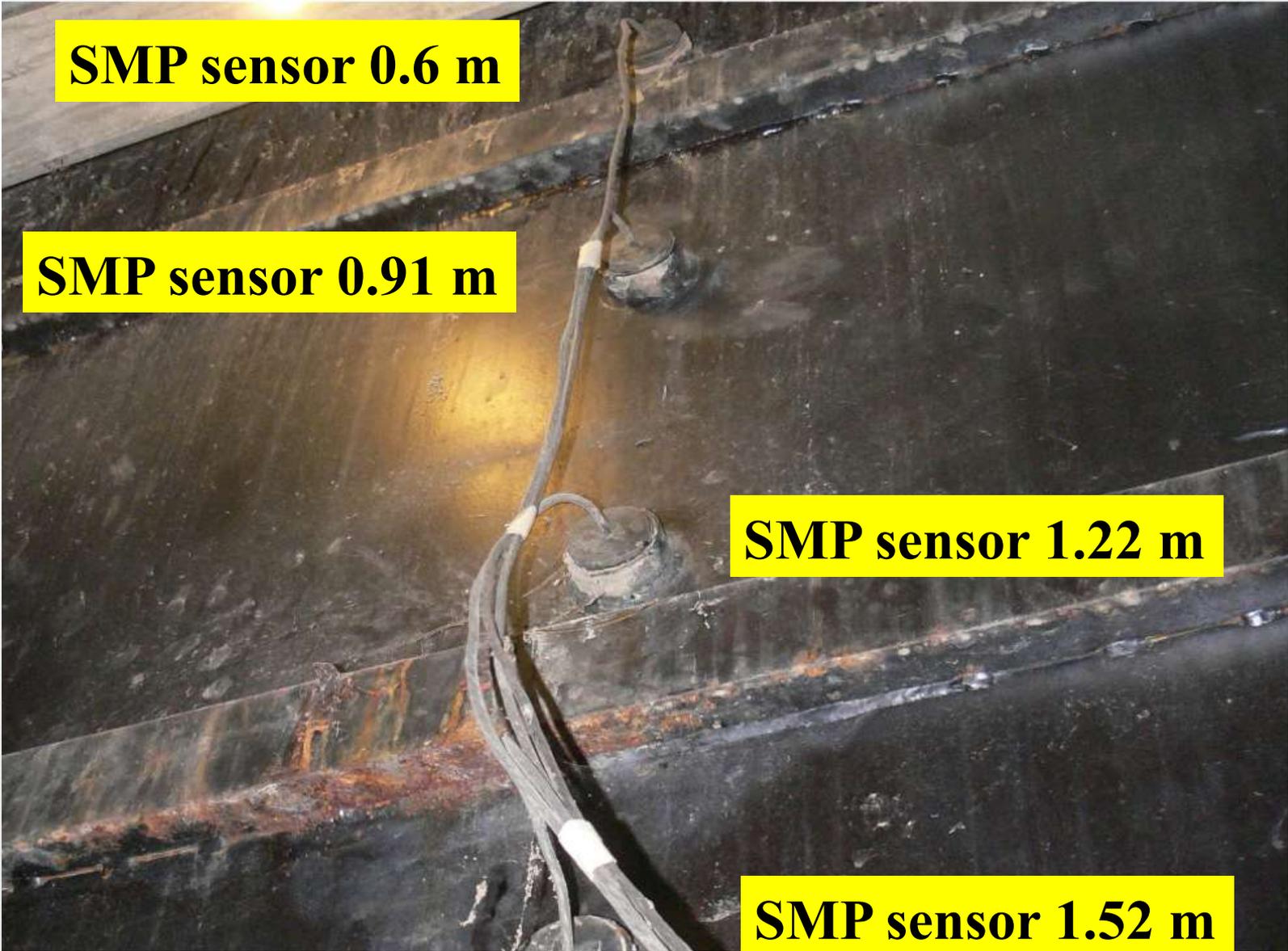
N2  
SDI    DI

N3  
SDI    DI

Electro-Magnetic Flow Meters



Weighing lysimeter (4 x 2 x 2 m) resolution of 0.05 mm of evapotranspiration

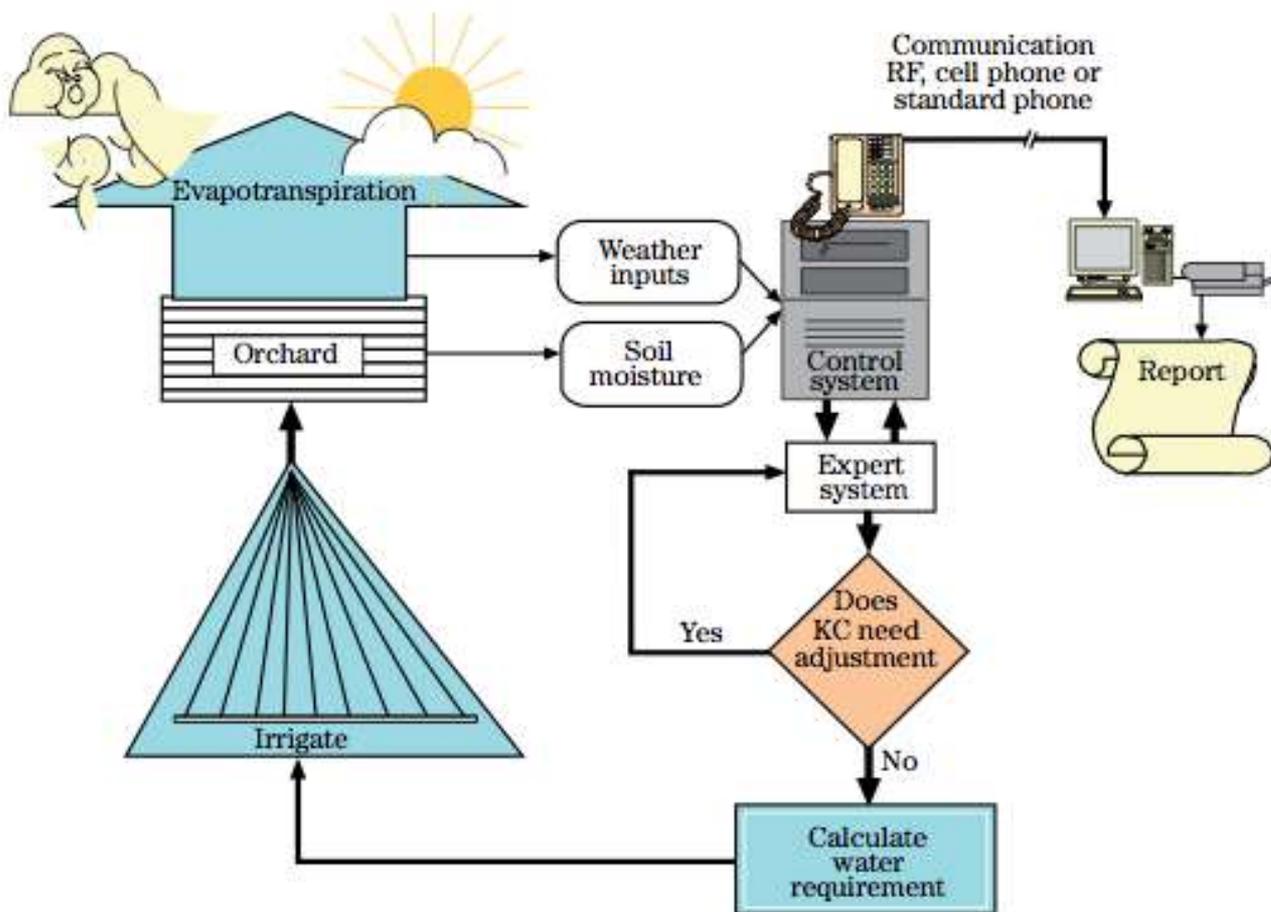


**SMP sensor 0.6 m**

**SMP sensor 0.91 m**

**SMP sensor 1.22 m**

**SMP sensor 1.52 m**



# Basic Soil & Irrigation Sciences

## C.J. Phene

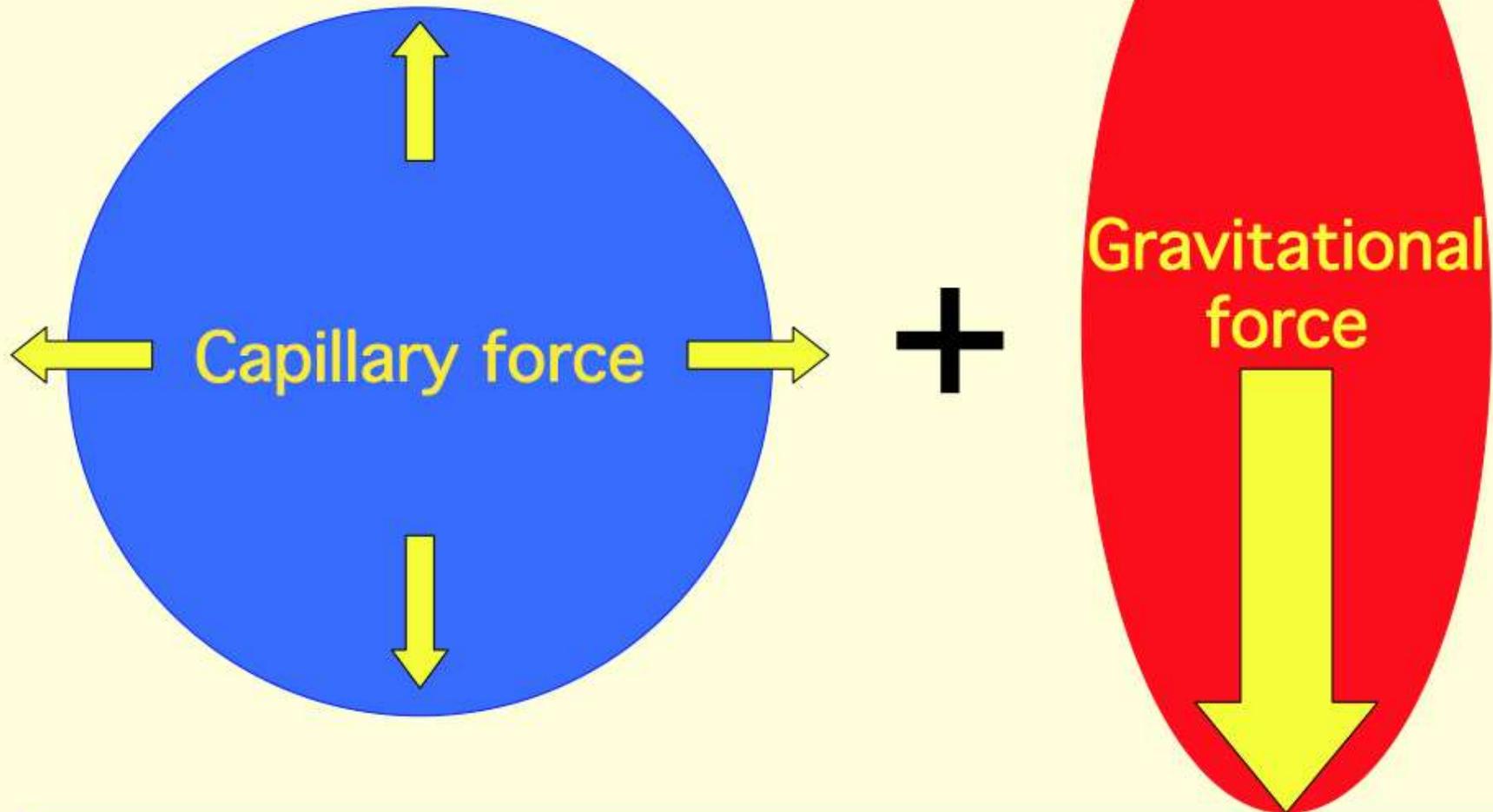
**DARCY'S LAW FOR UNSATURATED FLOW IN SOIL**

**THE RATE OF CHANGE  
OF SOIL WATER CONTENT**

$$\frac{\partial \theta}{\partial t} = -\nabla \cdot (K(\Psi) \nabla \Psi) + \frac{\partial K}{\partial Z}$$

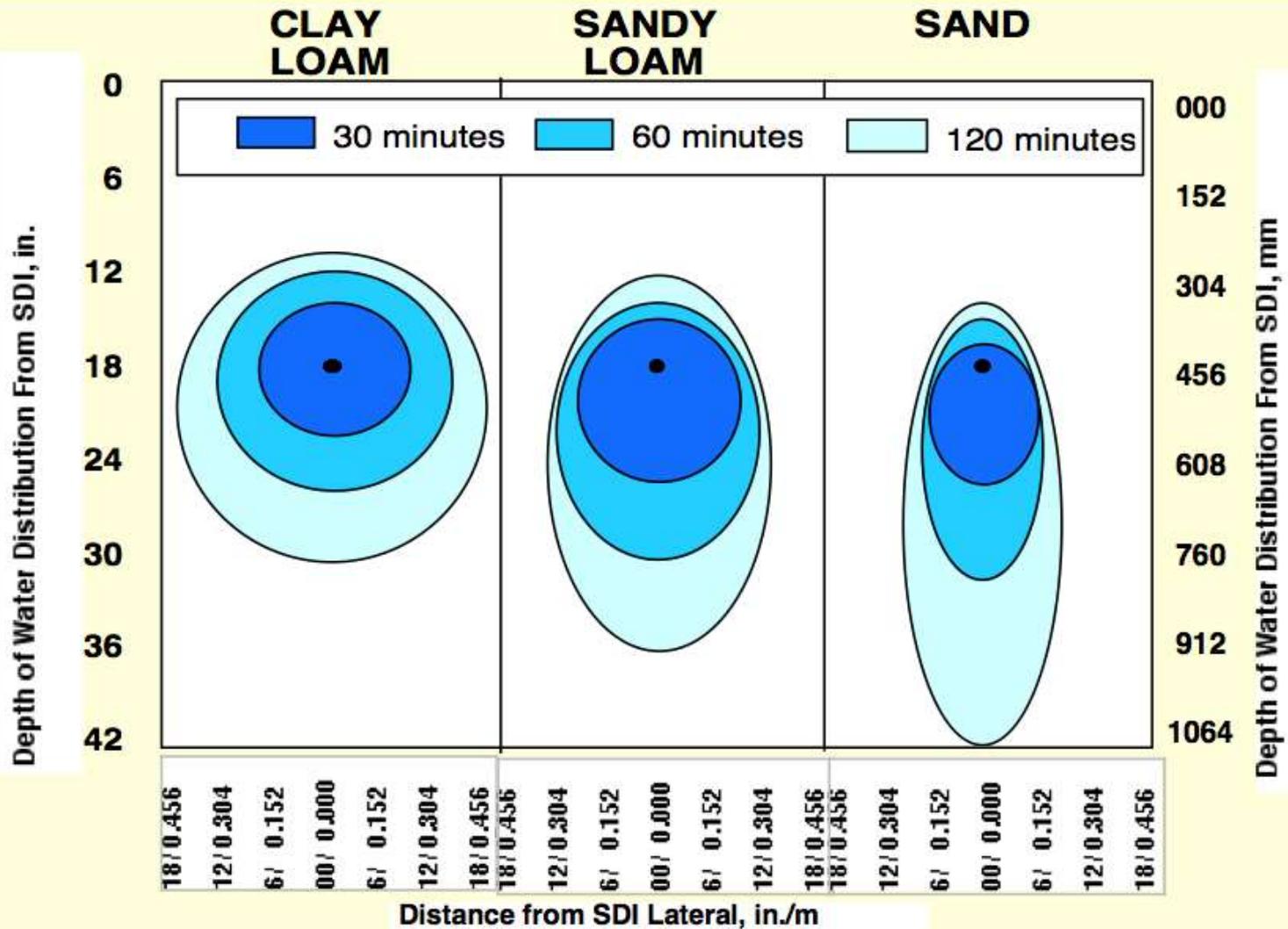
**CAPILLARY FORCE FIELD**      **GRAVITATIONAL FORCE FIELD**

# Darcy's Law Implication

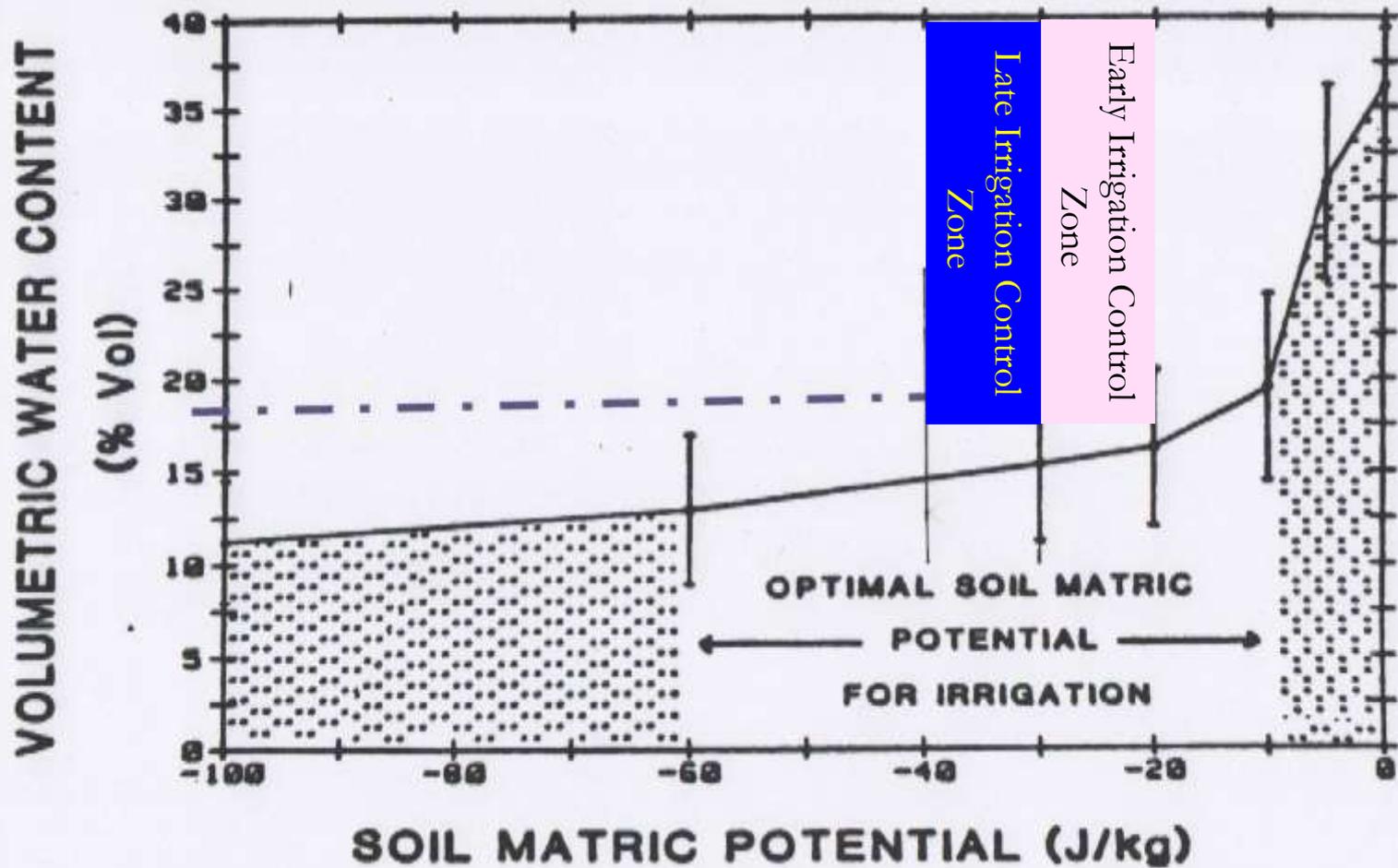


Irrigation Scheduling of Drip Irrigation Systems Should Minimize the Flow Due the Gravitational Force Field (or avoid Saturation Drainage)

# Patterns of Soil Water Distribution from a Subsurface Drip Point Source, as Affected by Irrigation Frequency and Soil Textures.



# Desorption Curve For a Hanford Sandy Loam Soil



Crop Evapotranspiration,  $E_{t_c}$ , Reference  
Evapotranspiration,  $ET_o$  & Crop Coefficient,  $k_c$   
R.C. Phene

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# POMEGRANATE WATER BALANCE (in.)

Year	ET <sub>o</sub> in.	Precip. in.	DI Irrig. in.	SDI Irrig. in.	ET <sub>c</sub> in.	Drainage in.
2010	49.73	17.34	1.0	1.0	2.1	N/A
2011	50.90	10.42	8.5	8.5	9.8	0
2012	54.60	8.97	18.6	17.7	19.7	0
2013	55.00	3.21	25.4	23.0	26.9	0
2014	57.80	8.62	33.4	30.7	35.9	0
2015**	49.61	3.52	34.76	31.46	34.8	0

2011 ET<sub>c</sub> values from 5/1 to 12/8 only.

\*Lysimeter ET<sub>c</sub> adjusted for orchard spacing

\*\*2015 Values are from January 1 to October 11th

Crop Evapotranspiration,  $ET_c$   
Reference Evapotranspiration,  $ET_o$   
Crop Coefficient,  $k_c$

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$$ET_c = ET_o * k_c$$

← The crop coefficient,  $k_c$ , is developed to relate  $ET_o$  to the crop

↑  
CIMIS, California Irrigation Management  
Information System ([www.cimis.water.ca.gov](http://www.cimis.water.ca.gov))

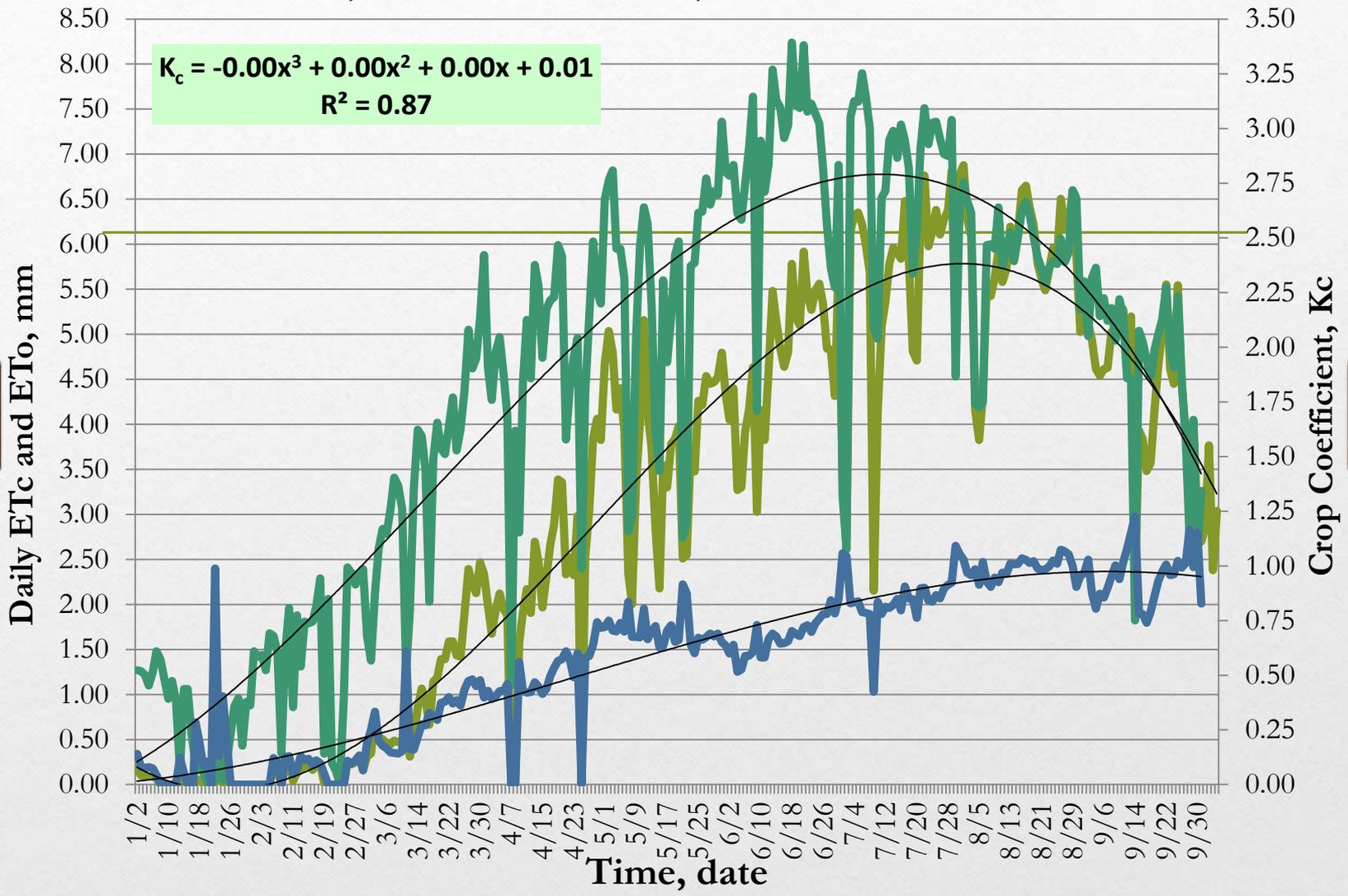
Crop Evapotranspiration,  $ET_c$   
Reference Evapotranspiration,  $ET_o$   
Crop Coefficient,  $k_c$

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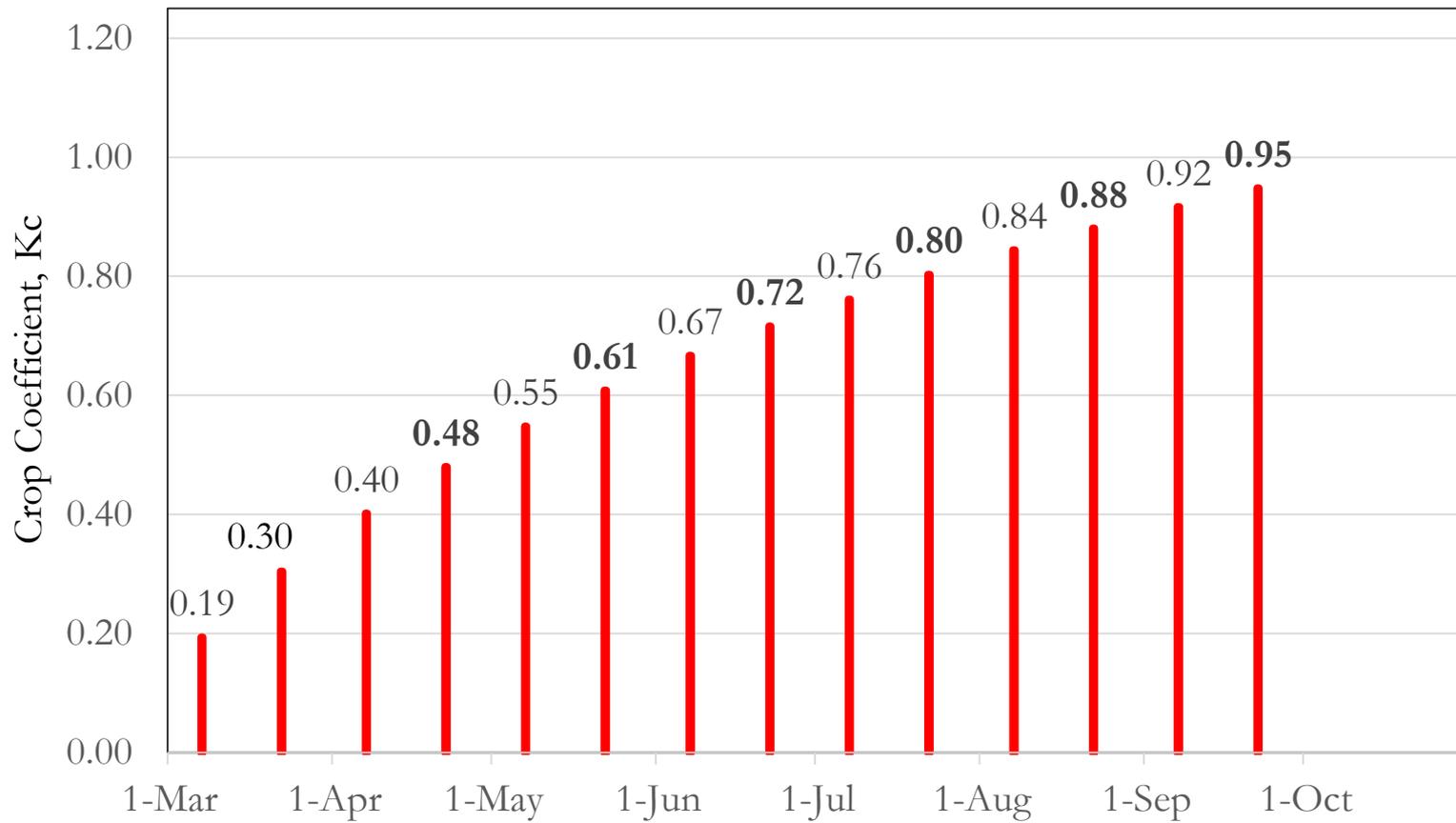
The daily grass reference ET (CIMIS  $ET_o$ ) and the orchard evapotranspiration ( $ET_c$ ) measured hourly by the weighing lysimeter were used to develop irrigation requirement and crop coefficient for maturing pomegranate.

# 2015 CIMIS ETo, Pomegranate ETc and Kc

— Etc, mm     
 — Eto,mm     
 — OrchaKc



## 2014 Bi-monthly Pomegranate Kc



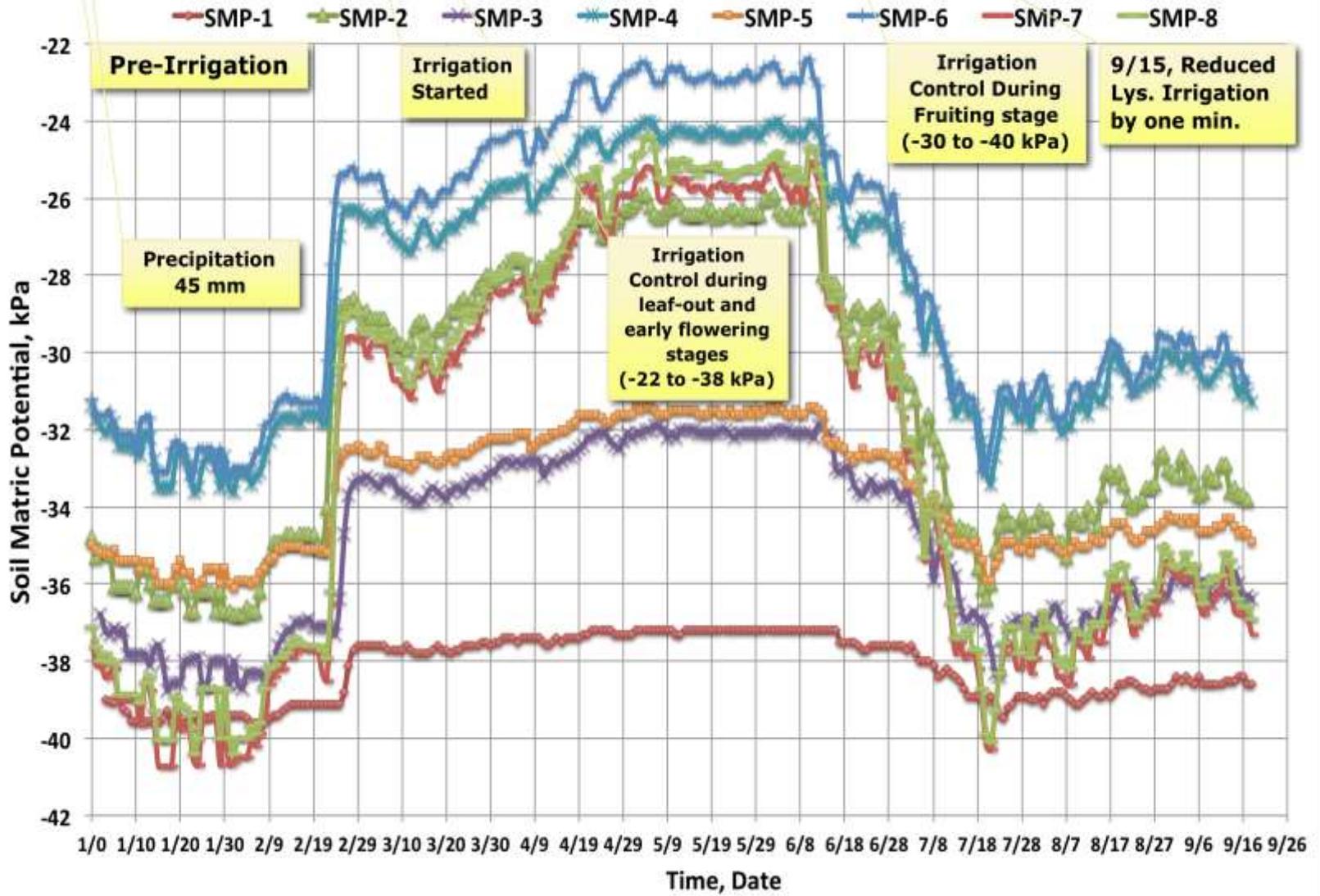
# Soil Matric Potential & Hydraulic Gradient

C.J. Phene & R. Schoneman

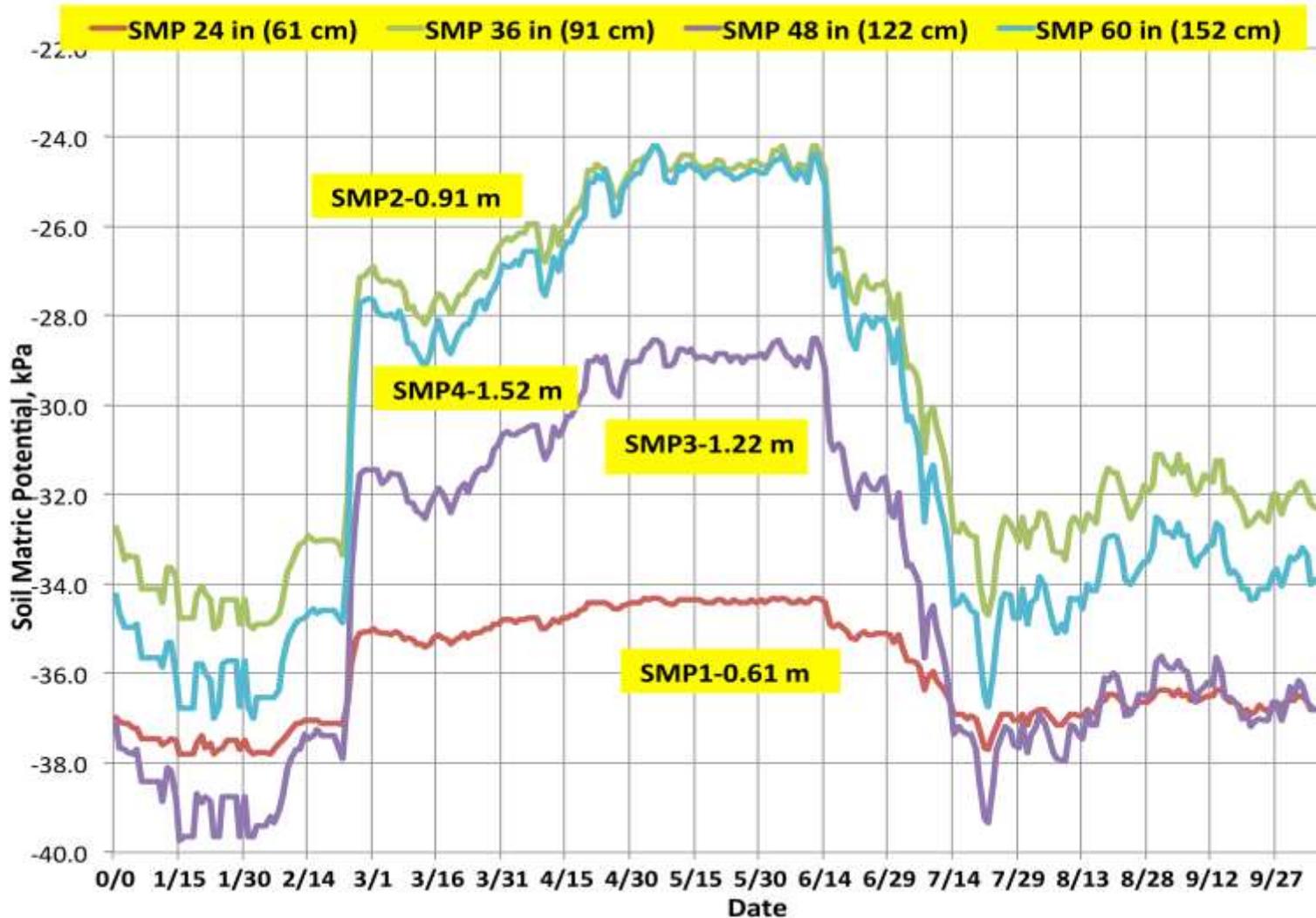
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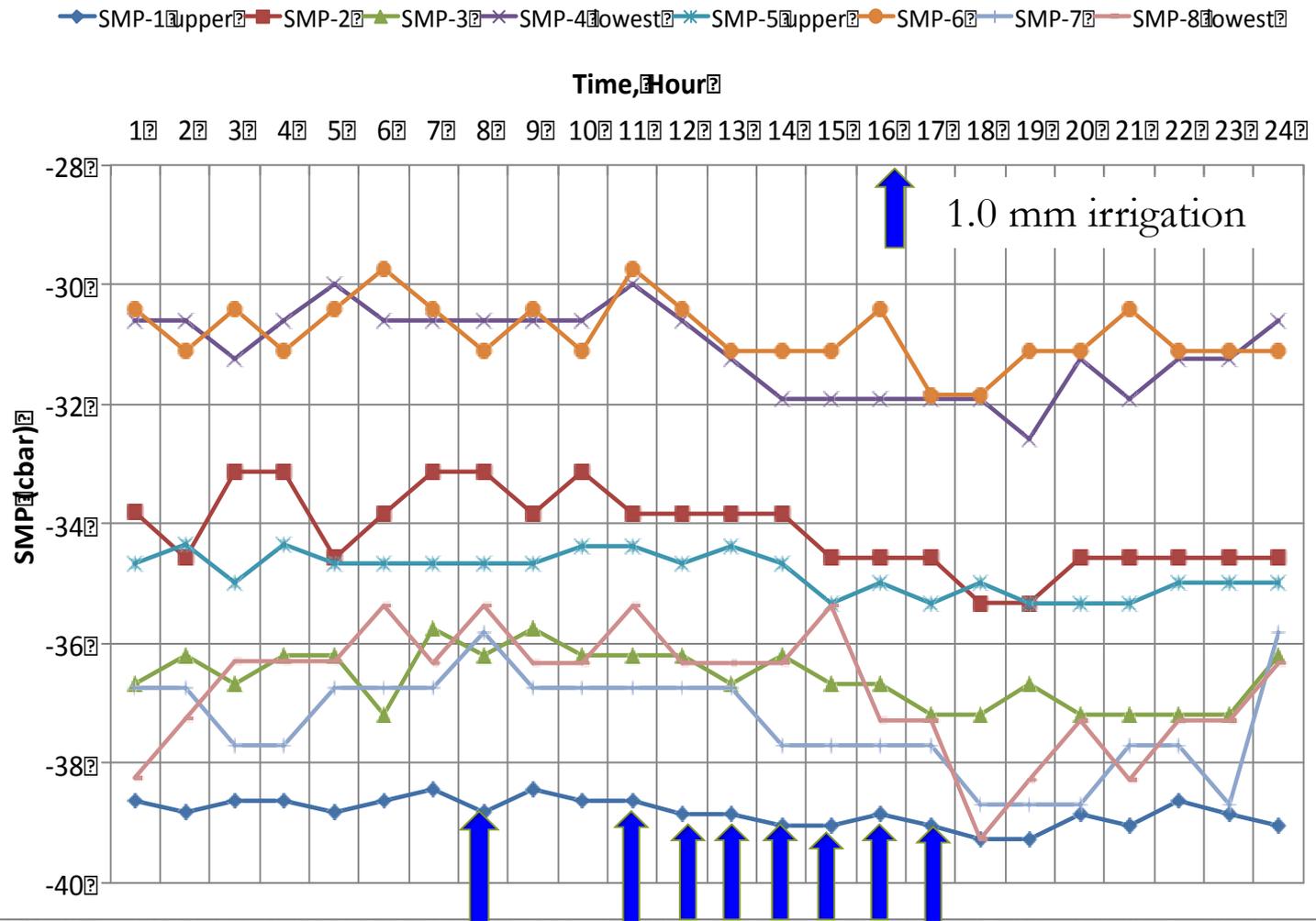
### 2015 Daily-Averaged Soil Matric Potential in Lysimeter



### 2015 Mean Soil Matric Potential (S & N)

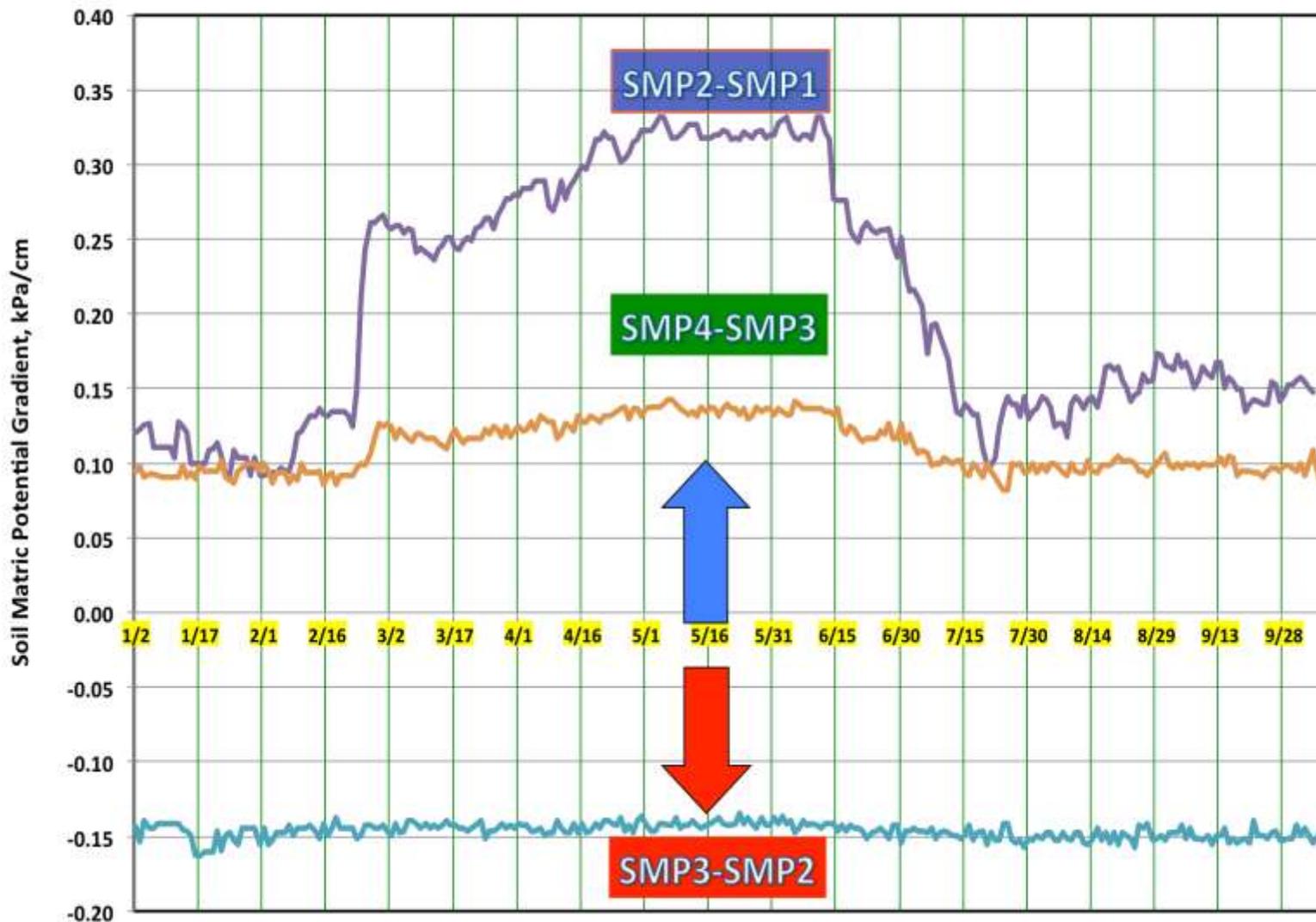


## Hourly SMP and Responses to 1.0 mm SDI Irrigation



### 2015 Soil Matrix Potential Gradient

—(smp2 - smp1)    —(smp3 - smp2)    —(smp4 - smp3)

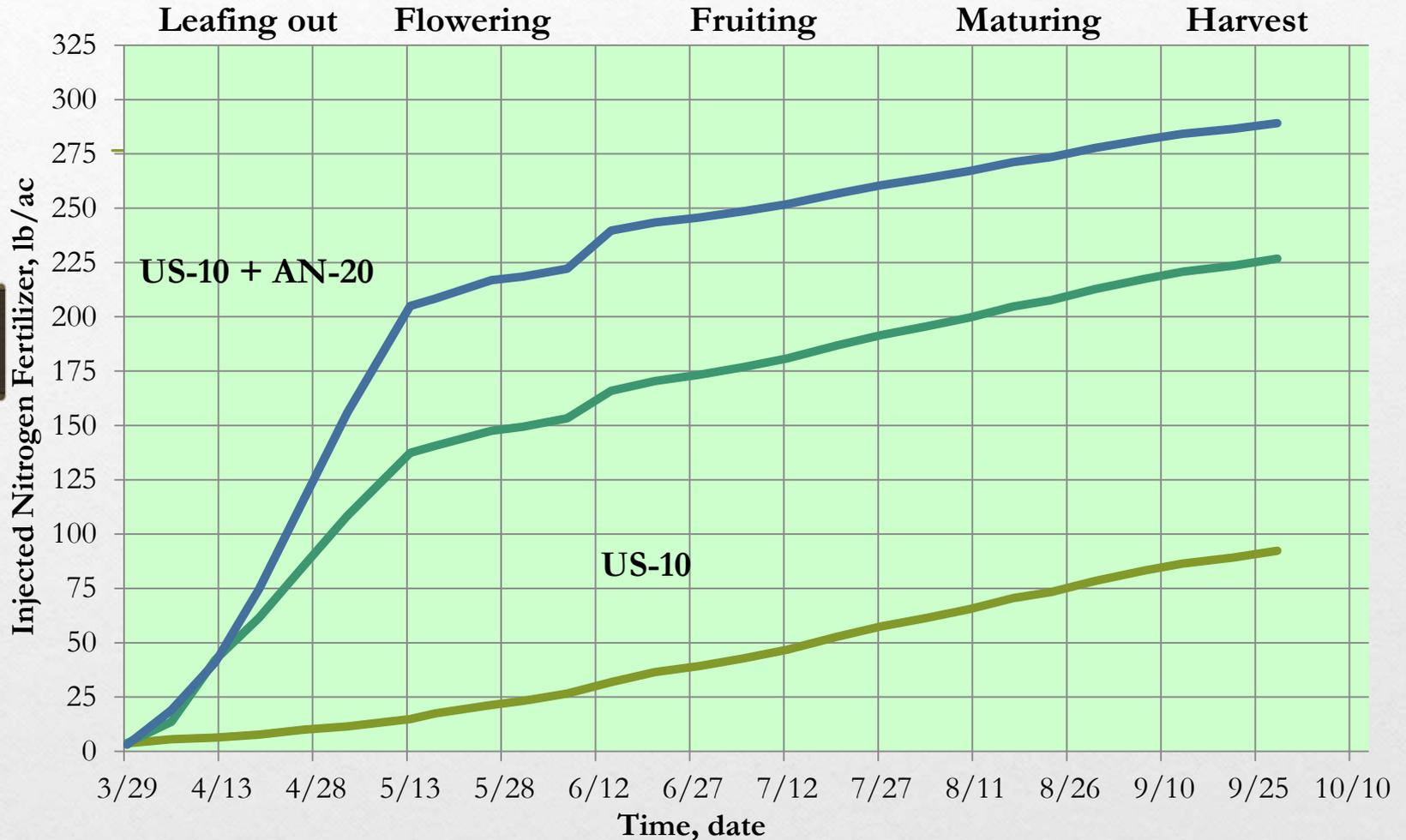


# Irrigation/Fertigation Control System

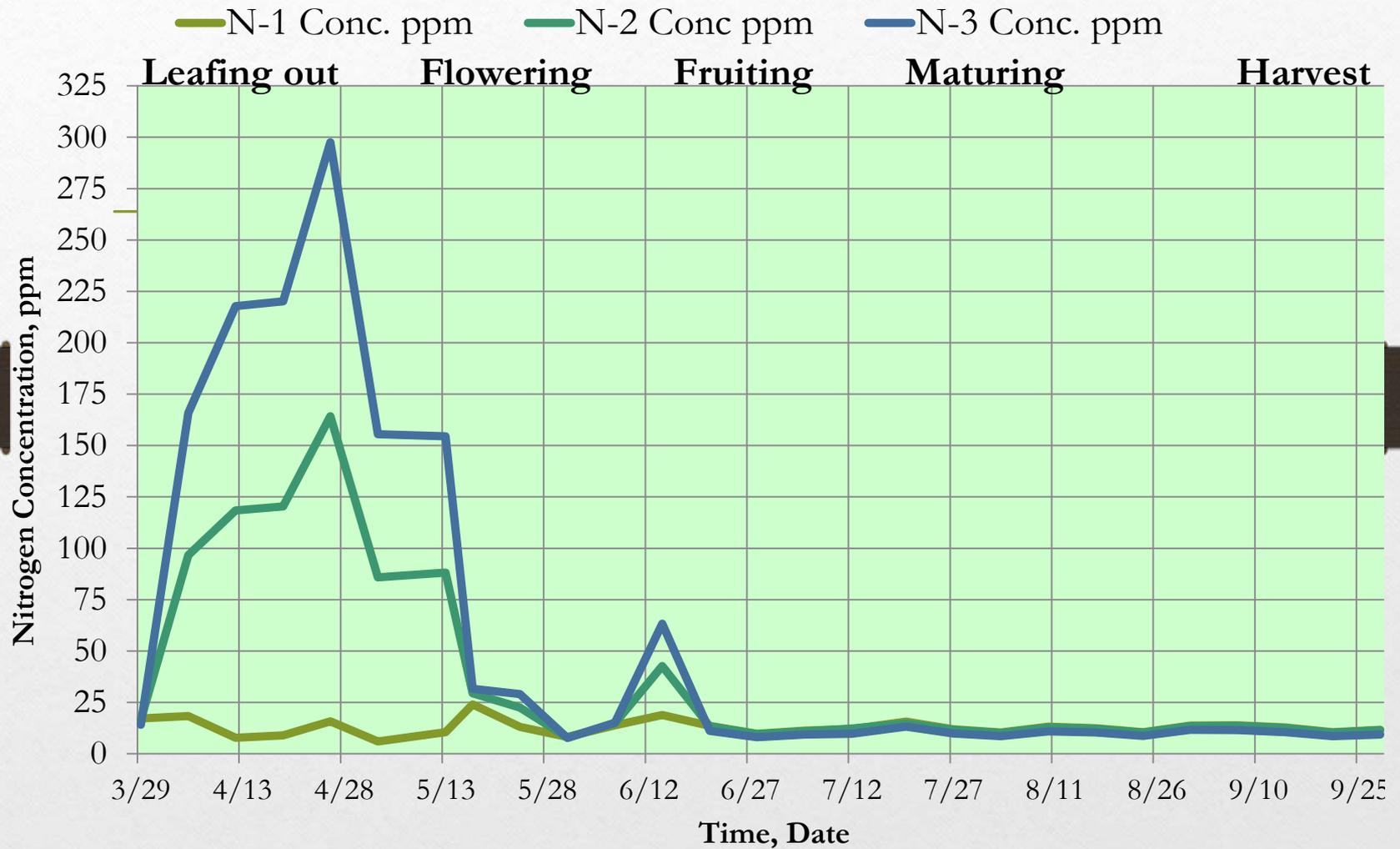


# 2015 NITROGEN

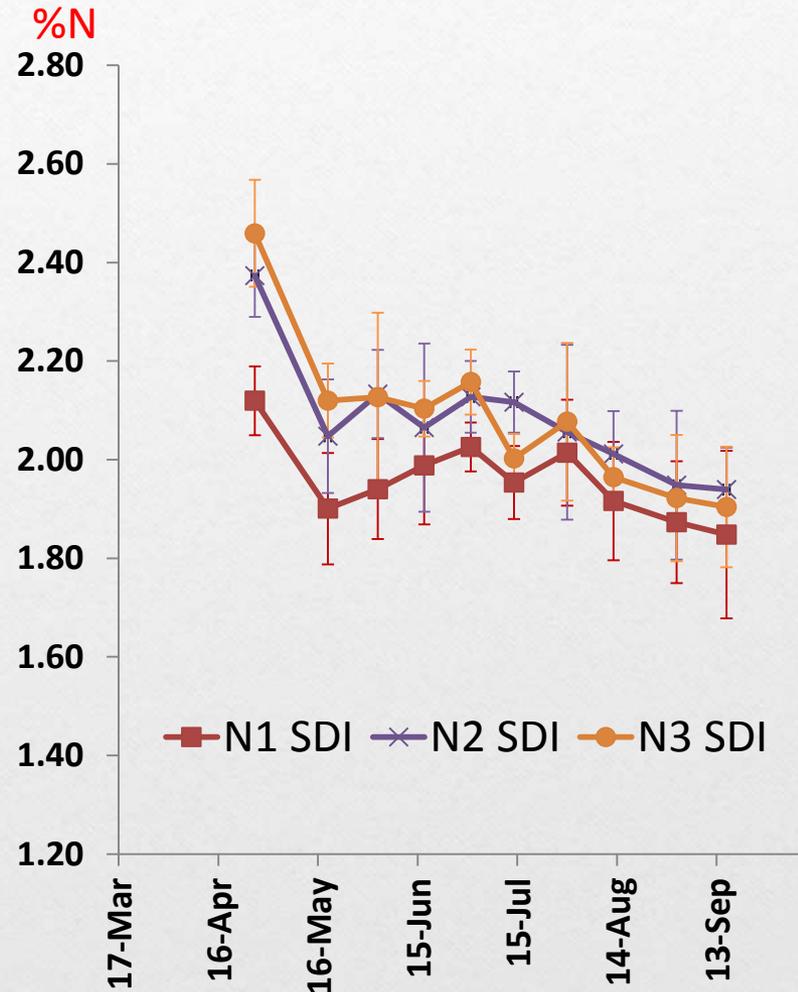
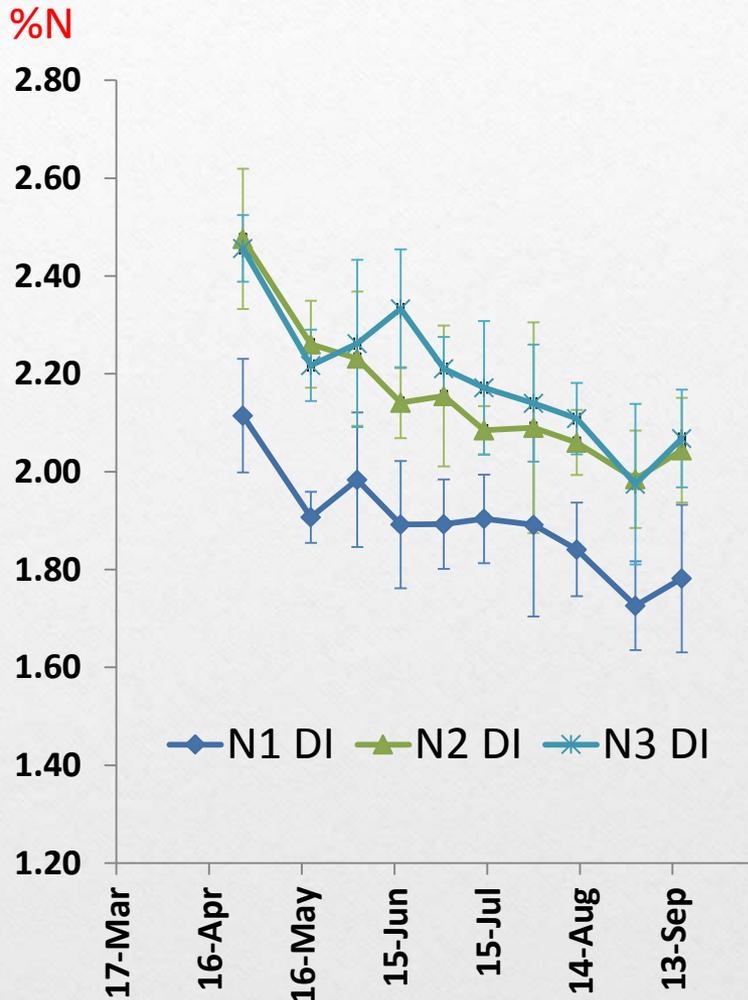
— N1 lb N/ac    — N2, lb N/ac    — N3, lb N/ac



# 2015 NITROGEN CONCENTRATION

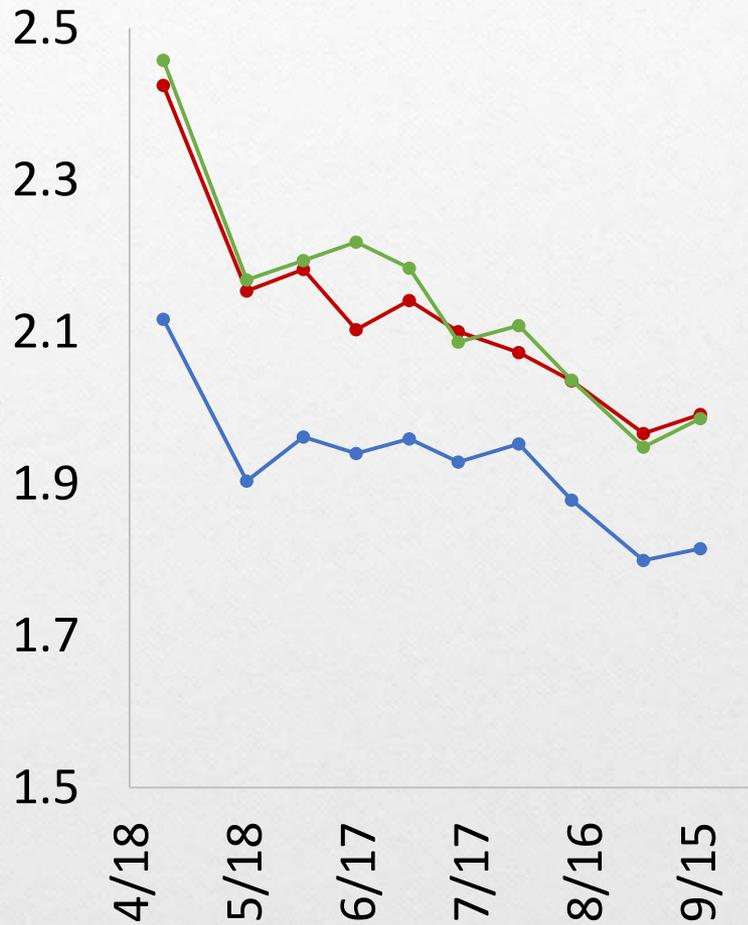


# Total Nitrogen in Leaf Tissue (2015)

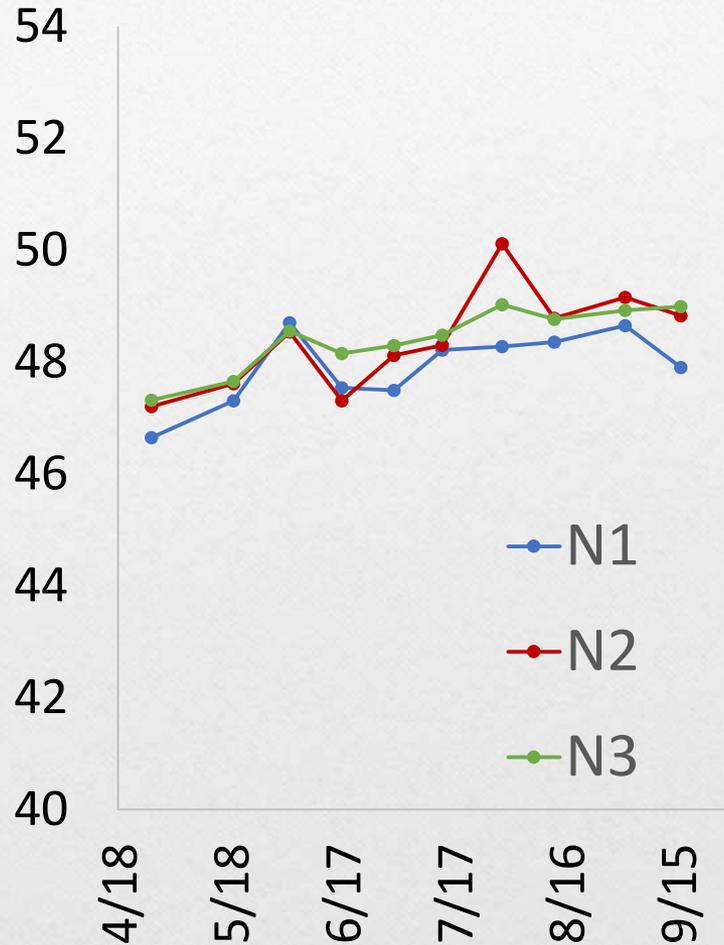


# Total Nitrogen & Carbon in Leaf Tissue (2015)

% Nitrogen



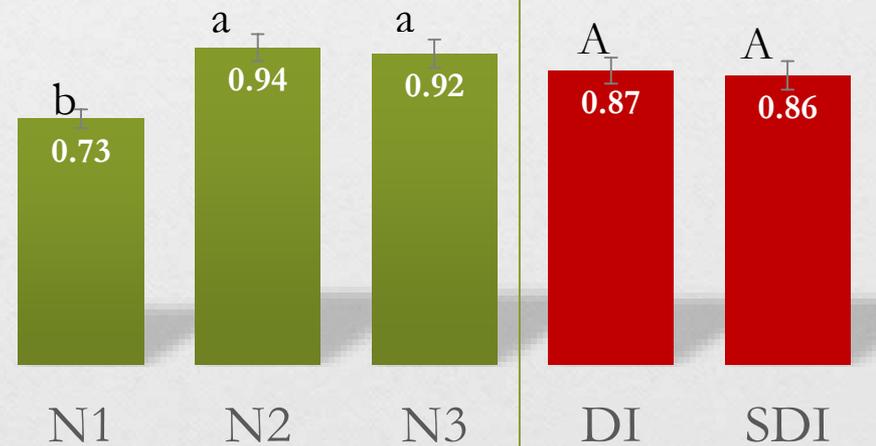
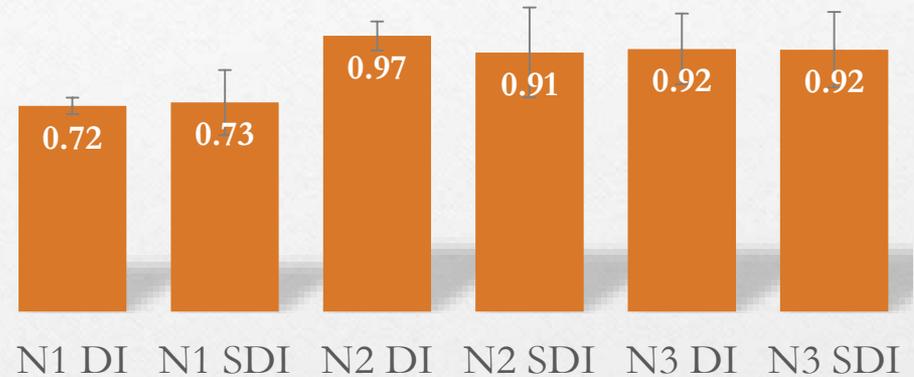
% Carbon



# Total Nitrogen in Fruit Parts (2014 harvest)

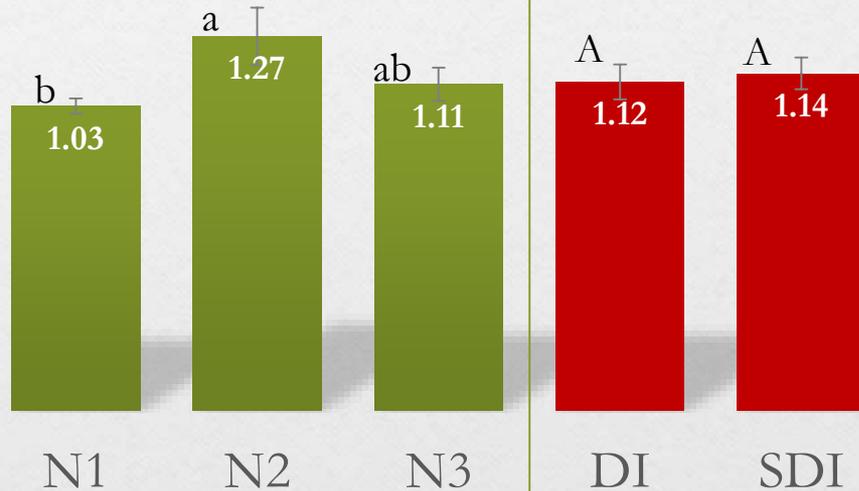
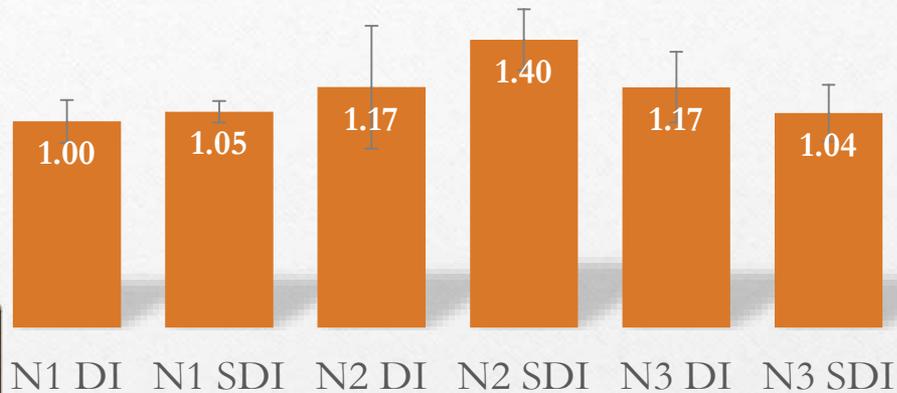


**%N in Pomegranate Peels**



# Total Nitrogen in Fruit Parts (2014 harvest)

## %N in Pomegranate Arils

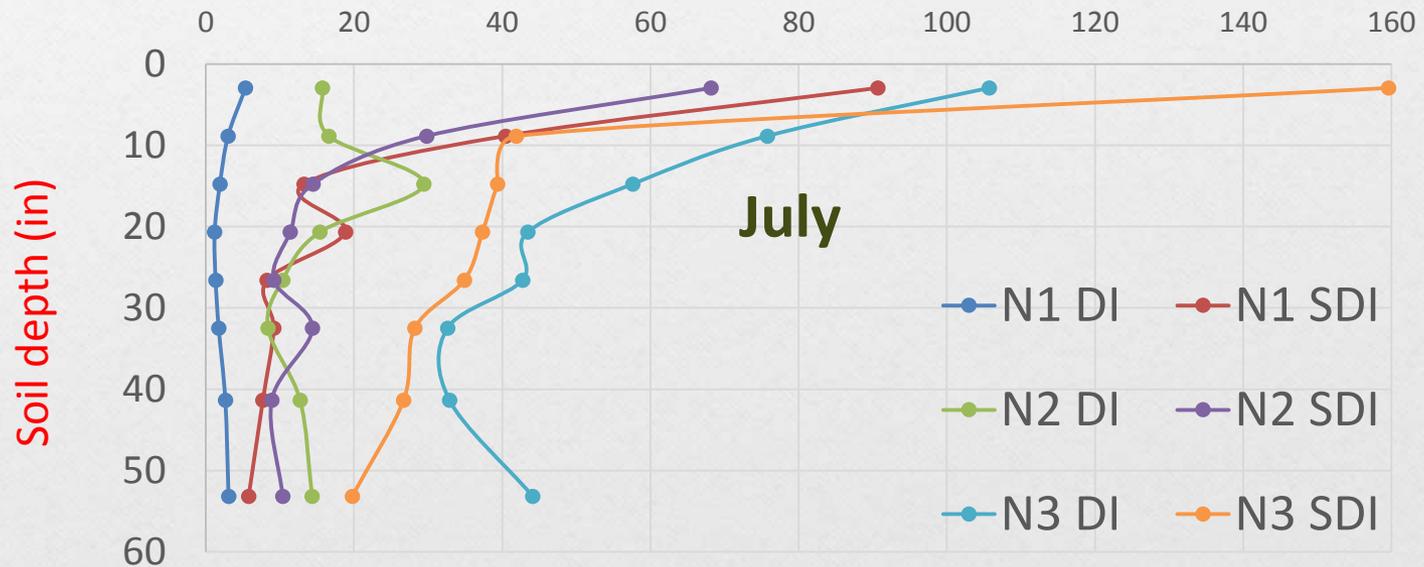
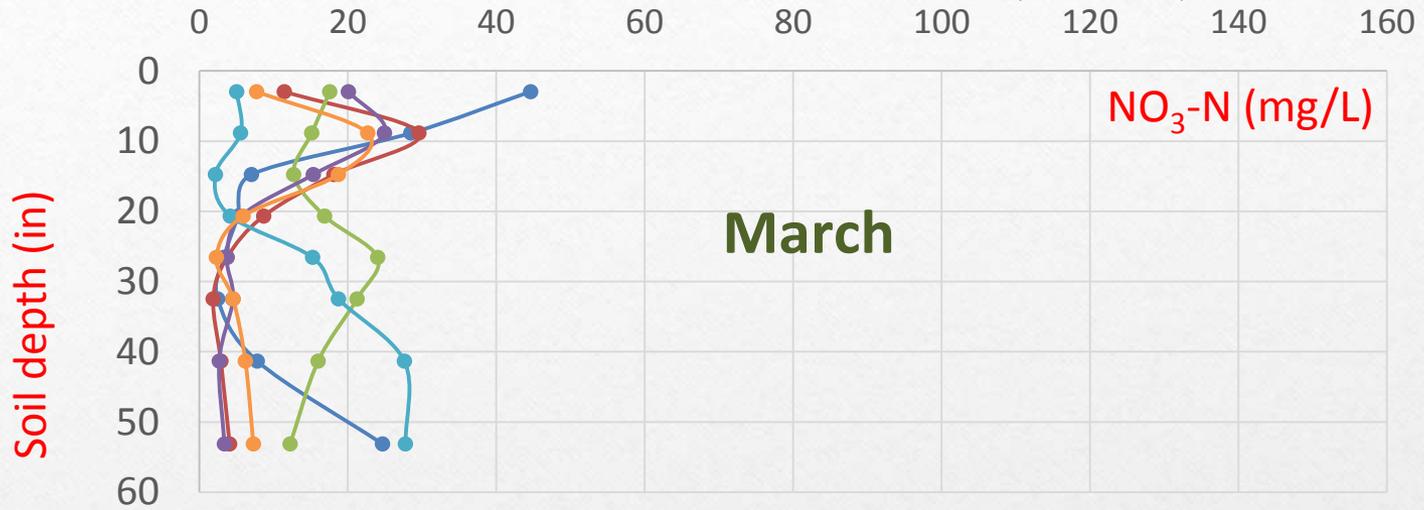


## Total Carbon in Fruit:

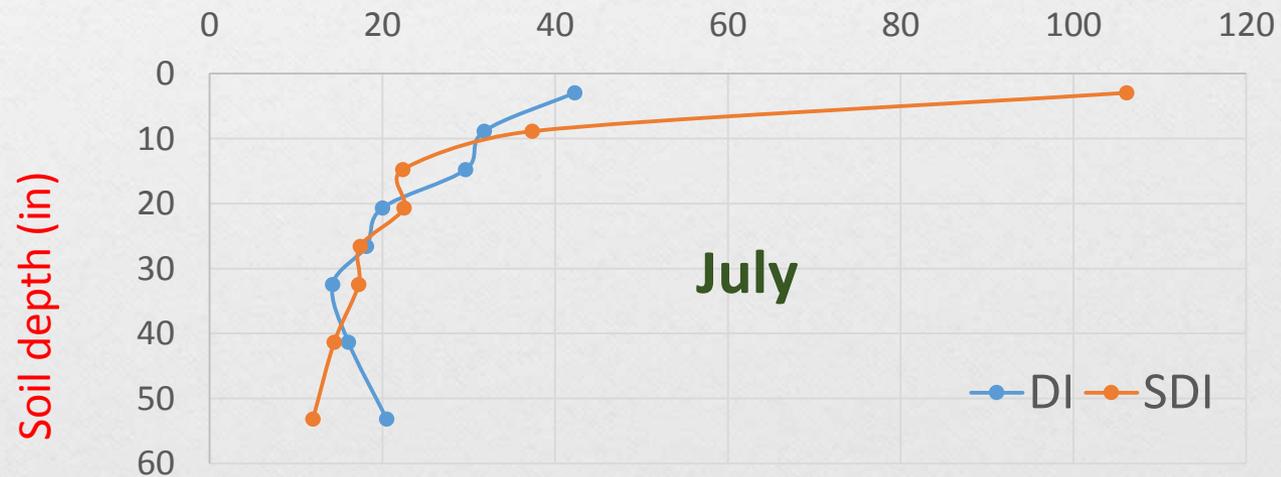
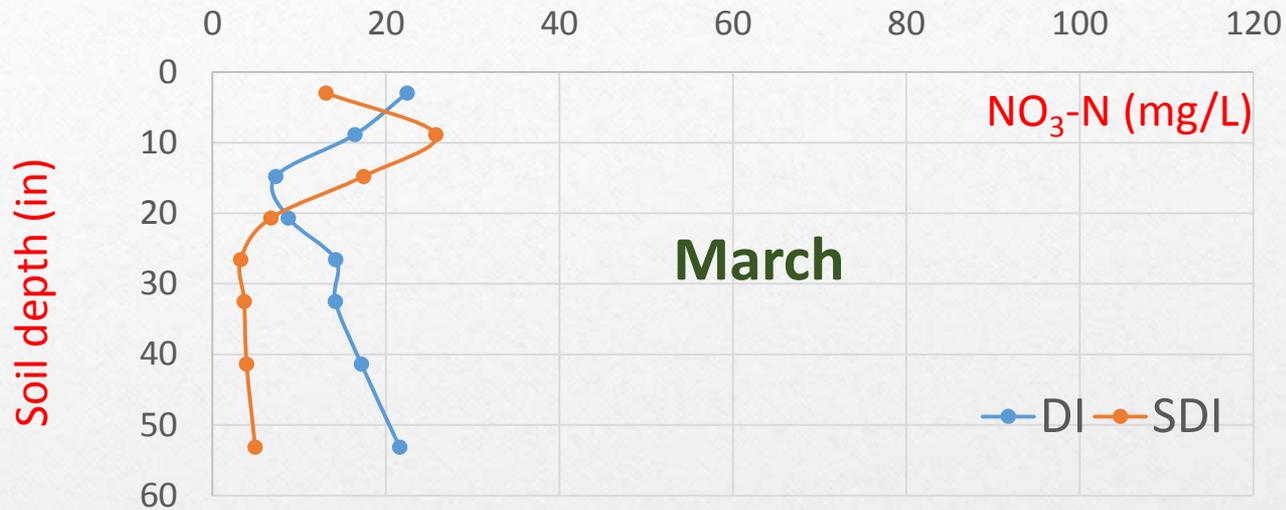
No significant difference among treatments.

TC in peels 45% & arils 42.5%.

# Soil Nitrate Profile (2014)



# Soil Nitrate Profile (2014)



# Yields, WUE, NUE



<b>2014 Yields</b>	<b>Marketable Yield, lb/ac</b>	<b>Total Yield, lb/ac</b>
<b>Irrigation Methods</b>		
Surface Drip (DI)	28,909a	37,119a
Subsurface Drip (SDI)	33,442a	42,591a
Prob > "F" value (5%)	NS	NS
<b>Nitrogen Levels (N)</b>		
(N-1) 35 lb N/ac	28,245a	40,344a
(N-2) 199 lb N/ac	30,532a	35,871a
(N-3) 305 lb N/ac	34,749a	43,352a
Prob > "F" value (5%)	NS	NS

## Effects of irrigation and nitrogen treatments on WUE and NUE of pomegranate in 2014

<b>IRRIGATION TREATMENTS</b>	<b>WUE- PRIME</b>	<b>WUE JUICE</b>	<b>NUE-N1</b>	<b>NUE-N2</b>	<b>NUE-N3</b>
	lb Fruit/ac-in		lb Fruit/lb N/ac		
<b>DI</b>	865.5a	226.7a	1060.6a	186.5a	121.7a
<b>SDI</b>	1089.3b	285.3a	1216.9a	214.0b	139.6a
Prob > F value	0.0086	NS	NS	0.0043	NS

# Effects of Irrigation and Fertigation Treatments on Residual Weed Biomass





# *Conclusions*

## *2014-2015*

Following six years of intensive pomegranate irrigation and fertigation research with high frequency surface drip irrigation (DI) and subsurface drip irrigation (SDI), results have demonstrated that the high frequency SDI system has the potential to provide:

1. Higher and more durable system performance.
2. Minimize nitrate leaching by controlling the gravitational gradient.
3. More efficient water use efficiency (WUE) than DI.
4. Minimum potential for nitrate-nitrogen (N) leaching than DI.
5. Lower weed population and mass than DI.
5. Improved orchard cultural practices, development and production.
6. No significant differences in pomegranate fruit and juice quality.